How to Read a Scientific Paper

(http://www.harcourtcollege.com/student/scipaper1.html)

Almost every scientific paper adheres strictly to a traditional format: title, authors, abstract (summary), introduction, materials and methods, results, discussion, bibliography. Some journals abbreviate and de-emphasize methods and bibliography, and many journals impose a word limit on papers.

Scientists read papers with differing degrees of attention and skepticism. Sometimes we read just to find out what is happening in a field that is tangential to our own, and our reading is rather casual, like the way we might read a magazine. Often, however, we want to learn the results and interpretation of other researchers working on a particular problem of intense interest.

At our most critical, scientists may bring a kind of intellectual *machismo* to a published paper. In this mode, we are ready to assume that authors, reviewers, and editors have all had major lapses in thinking, and only our own critical sensibility can prevent our friends and students from sinking into a scientific swamp. We focus on the data presented in the results section, usually presented as graphs, tables, or photographs. We ask whether the data is believable, and whether the authors' interpretation of their own data is correct. We may even say, "I *never* read the introduction or discussion of a paper. I only want the facts, so I only read the results." Or even, "I only look at the graphs and figures."

Looking at the data carefully is important, as is learning to evaluate the data independently of the author's own interpretation. In a Ph.D. qualifying examination, for example, a graduate student may be given a paper without a discussion section and asked to write the discussion himself or herself. But most of the time, the context of the paper, set forward in the introduction and elaborated in the discussion, is what makes a paper most interesting and stimulating. While many students learn that they should first read the abstract of a paper to learn what it says before deciding whether to read the entire paper, the introduction is actually a better starting point, since the introduction frames the scientific questions that the paper addresses.

What papers should you take the time to read carefully? When you are searching for information about a topic of interest, you will find it useful to alternate between cursory readings of papers from which you just want to know conclusions or methods, and critical readings of crucial or controversial papers.

For a paper that you decide you should read carefully, we can provide some general guidelines. First, understand that you may have to read a paper several times before it begins to come into sharp focus. At first encounter, many papers seem obscure and unnecessarily detailed. Your first task is to discover the paper's main point: What question is it addressing, and what answers does it offer? Set yourself the task of actually writing down the main question asked in the paper and your own one- or two-sentence summary of the paper's conclusions.

Then state the general experimental strategy, the methods by which the authors addressed their question in a way that leads to the answer. Resist getting involved in too much detail while examining the methods—just state the general approach.

Next, observe how the experimental approach works for one or two experiments—summarized by the figures in a paper. Ultimately, you will want to be able to discuss the data presented in each of the figures and tables: What are the authors measuring? How does the data contribute to the conclusion? Do you believe the data? Do you trust the conclusion? Usually, you will not be able to make confident judgments about the believability of the data until you have actually had some related laboratory experience.

Finally, place the paper in the context of other things that you have been learning. Why do you think this paper is important enough to read critically, rather than just glancing at its conclusions? How does the paper relate to information that you have learned elsewhere or to the "big picture" developed in your text or in your class's lectures?

Remember, just because something is published—either in a textbook or in a peer-reviewed journal article—does not mean it represents the final truth about a subject. Scientific understanding changes, sometimes dramatically, as new techniques allow the collection of new information and as new insights accumulate both within a given area and from other fields. On the other hand, a new technique—even one that is used by many critical scientists in many laboratories—can sometimes mislead a whole field because of an unnoticed artifact. A prominent scientist once embarrassedly described the status of a particular field that had been misled by a flawed technique, saying, "Unfortunately, the scientific literature is far ahead of our understanding."

Still, peer-reviewed papers are the currency of scientific progress. Students and researchers alike must go to such papers for information and understanding, but they must continue to be skeptical, even after a paper is published. Science in general is self-correcting, especially in fields like cell biology, where new understanding can lead to valuable practical applications, or disastrous consequences, in medicine or agriculture. In science, a misunderstanding, artifact, or deception generally cannot persist for long, especially as more people employ a skeptical—but respectful—approach to reading the scientific literature.

What Is the Function of Each of the Parts of a Paper?

Part	Function	critical reading	relaxed reading
Title	tells what the paper is about	allows decision of whether to read more	allows decision of whether to read more
Authors	tells who did the work and who assumes responsibility for it	not particularly important	important: some authors are consistently interesting, no matter what their subject
Abstract	summarizes the results of the paper, and sometimes the interpretation	important: most salient facts in one place	not as important as the frame of the paper in the introduction
Introduction	sets the framework of the paper: why it is important or interesting	not important: the reader should be able to place the paper in context the most	important part of the paper
Materials and Methods	gives details of materials used and of experimental methods	worth detailed attention; tells exactly how experiments were done; the place to look for weaknesses in approach	important only when methods are not standard or paper is otherwise unbelievable; usually obscure to someone not working in the field
Results	reports what the researchers actually found; data may be in graphs, tables, or photographs	ultimately the most important section of the paper: "just the facts"	important: a careful reader will evaluate whether the results actually support the stated hypothesis and if they also support alternative views or raise additional questions
Discussion	discusses two sets of issues: (1) the adequacy of the experiments themselves and (2) the relationship of the results to other work in the field	not so important: the reader should evaluate the data and place them in context	the best window into the author's context, revealing the level of confidence in the conclusions
Bibliography	lists other papers relevant to experiments or conclusions	shows where to find details of methods and context	source of additional information